BioEco Forum on Environmental Applications of Remote Sensing: Summary and Recommendations

By
Dr. Maury Nyquist, USGS/CBI

Introduction: Many Federal, state, and private organizations are heavily involved in remote sensing technologies to advance their missions. However, remote sensing science, technologies and applications are rapidly changing and advancing; new Federal, commercial, and foreign satellites are operational and many more new sensors are planned. Complex new technologies, such as LIDAR and hyperspectral imaging, are being developed. These powerful new remote sensing technologies present unique opportunities for supporting environmental science and monitoring to aid private industry, educational institutions and all levels of government. To improve coordination in remote sensing activities that support environmental science and monitoring, the Biodiversity and Ecosystems Work Group**,** in collaboration with USGS, sponsored the Forum on Environmental Applications of Remote Sensing to share information on advances in remote sensing and demonstrate current remote sensing activities in the Federal, State, university and private sectors.

The Forum was held on May 25-26, 2000 in conjunction with the American Society of Photogrammetry and Remote Sensing (ASPRS) Annual Conference on May 22 – 26, 2000 at the Omni Shoreham Hotel in Washington, DC. Approximately 60 individuals from 15 different Federal agencies and other organizations registered specifically for the Forum. Attendance at the Forum's sessions ranged from 100 to 200 individuals including other ASPRS conference attendees. Twenty-six educational sessions were presented during the two-day Forum.

Summary The program on Thursday morning was presented by NASA program managers and scientists. Half of the sessions focused on the characteristics, capabilities and early applications of the new Landsat 7 system. Highlights included the system's: higher quality data, new operating procedures which make the data available at much lower cost, reliable multi-seasonal coverage of most of the earth, and the compatibility of the new data with previous systems' data which enables reliable monitoring of the earth's environment over a nearly 30 year time frame. The remainder of the sessions focused on new satellite systems, especially NASA's Terra and SpaceImaging's IKONOS systems. A wide range of applications were presented that involved land cover/use inventory and monitoring and demonstrated the great potential for synergistic uses among the existing new and soon-to-be-launched satellite systems. The morning's sessions were followed by a luncheon talk by Dr. Rosina Bierbaum, Office of Science and Technology Policy, on *Biological Applications of Remote Sensing: A Policy Perspective*. **(Note: since I was unable to attend the session, if you want to add a highlight or take home lesson(s) from the session, someone that was in attendance will need to provide it)**

Representatives from private industry presented the six sessions on Thursday afternoon. Four of the sessions focused on airborne systems: digital mulitspectral cameras, multispectral video, multispectral scanners, LIDAR (Light Detection And Ranging), and radar. The utility of using airborne digital multispectral cameras, multispectral video, and multispectral scanners for a wide range of environmental inventory and monitoring activities (e.g. noxious invasive weeds, crop identification and precision agriculture, water quality, vegetation classification and characterization including disease and insect infestations, fire applications, wildlife habitat determinations, etc.) was presented. The sessions also showed that most of these systems are best suited for applications related to small - medium sized areas and caution must be exercised in determining which system or set of systems best matches the application needs. The new and rapidly advancing LIDAR technology is proving to be a valuable tool for accurately determining ground elevations (even in areas with a rather dense vegetation canopy), and vegetation canopy heights (including under story canopies, vegetation density and vegetation biomass estimates - a derivative of vegetation structure). Radar shares these capabilities but at coarser resolutions, while also having sensitivity to plant and soil moisture, which provides capabilities for wetlands mapping as well as drought and flood monitoring. Radar's cloud penetration capability is also very important. The fifth presentation dealt with the promises and pitfalls of automated image classification, indicating that although there continues to be promising advances in automated classification procedures there is still a long way to go. The sixth paper dealt with the nearly realized vision of an accurate, moderate resolution, global landcover data set that should be complete by 2003. This nearly completed global data set resulted because of the availability of five essential elements: moderate resolution image (MRI) base, historic global landcover from MRI, inexpensive MRI – now and into the future, effective landcover change analysis techniques, and a valid multi-stage sampling approach. The final presentation gave examples of how government, university and private industry collaborations are fostering the development and enhancement of private industry capacity in the field of environmental applications of remote sensing.

Friday's sessions were presented by leading university and government scientists, who are doing a wide range of basic, as well as practical environmental applications with the sensor systems discussed in Thursday's session. Friday's first session documented the more than 140 year history of the development of environmental applications of remote sensing – from tethered balloons with cameras to satellites with multi-sensor systems. A session on the need and use of multi-resolution data sets for environmental assessment demonstrated that landcover characteristics at a variety of scales and themes are essential for environmental models, including land-atmosphere interactions, biogeochemical process, net primary productivity, and hydrological assessment. This situation will dictate that future directions in large-area landcover characterization include: increased emphasis on the need for product flexibility and versatility, products in which user requirements are balanced with the technical limitations of remote sensing, effective use of new sensors, and the application of improved validation strategies.

There were three sessions on radar. One provided a broad overview of the different types of radar systems and the development of a wide variety of environmental applications possible with these systems. Another focused on the potential for using radar to characterize forests and the problems associated with the use of existing satellite radar systems for this application. The final session described how improvements in landcover and landuse classifications were obtained when radar was used in combination with optical (i.e. Landsat) systems.

There were two LIDAR presentations. One focused on the use of airborne LIDAR to penetrate dense forested canopies to derive better digital terrain information, which was used in a GIS application to develop a least cost model for the construction of a railroad line. The other focused on the potential for a new satellite LIDAR system (i.e. Vegetation Canopy LIDAR) to provide data at the spatial scales and coverage most relevant to global assessments of forest biomass and inventories of above ground carbon, as well as using it to determine levels of productivity and disturbance regimes.

Other sessions covered the following variety of topics. The use of hyperspectral imagery was discussed in the context of detailed forest vegetation classifications and how hyperspectral imagery presents challenges and opportunities for detailed forest analysis, including both productivity and species discrimination. The large area monitoring of temperate forest change and why Landsat 7 is so important to this and related applications (e.g. continuity of data, availability of multi-seasonal data for most of the earth, low cost, ability to share data, and high data quality) was presented. An NGO policy perspective was given on how they value the availability of remote sensing systems, such as Landsat and others, to provide the information necessary for them to carry out their conservation objectives. Information was provided on the use of visualization techniques to demonstrate how remote sensing information could document landuse change and forest fragmentation.

Recommendations: There were a number of explicit and implicit recommendations that were threaded among the different presentations. These recommendations focused on continuance of a "Landsat-type program", future directions in large-area characterization and monitoring, specifications for new and more effective radar systems, continued support for new systems (both government and commercial), and the need to be able to effectively integrate the use of multiple remote sensing systems for effective environmental applications.

The need for the continuance of a government sponsored "Landsat-type program" was mentioned in several presentations. The new Landsat 7 program has enabled a major resurgence in medium- to large-area characterization, inventory and monitoring for a wide range of environmental applications. The primary reasons for this resurgence included: continuity of data, availability of multi-seasonal data for most of the earth, compatibility with legacy data, low cost, ability to share data, and high data quality. Therefore if these important types of environmental applications are to continue in any meaningful way, the continuity of a "Landsat-type program" is essential.

The need for and use of multi-resolution data sets for large-area environmental assessment demonstrated that landcover characteristics at a variety of scales and themes are essential for environmental models. These data sets are useful for modeling a variety of processes including land-atmosphere interactions, biogeochemical process, net primary productivity, and hydrological assessment. Therefore future directions in large-area landcover characterization should include increased emphasis on the need for product flexibility and versatility, products in which user requirements are balanced with the technical limitations of remote sensing, effective use of new sensors, and the application of improved validation strategies.

Existing satellite radar systems are not truly effective for inventory and monitoring of vegetation, which is a key element in most environmental applications. In order to optimize radar's capability to characterize vegetation, new satellite radar systems should be configured accordingly. Multi-band is essential and having P, L, and C band would be very beneficial. Systems with three bands would be expensive, but each band is essential to capture a different and valuable piece of information. Specifically, the P band provides the best information about forest development, the L band provides information about internal crown characteristics, and the C band provides some information about crown surface and aids in separating forest from other vegetation and from non-vegetated or disturbed conditions. For vegetation, the X band is not very useful. Multi-polarization is essential. Different forest types and different forest structures will affect polarimetry differently. Therefore, there is a need for both like- and cross-polarized imagery. The ability to do repeat-pass interferometry would be very useful, because it has been found that radar coherence does vary with forest type. This capability could be accomplished in either of two basic ways. A single satellite with orbital characteristics that allowed repeat pass of the same area within a relatively short time frame (e.g. a few days to a few weeks) or with two satellites flown in tandem with repeat pass times of a few minutes to hours.

New government satellites like the Terra system and the soon to be launched VCL (Vegetation Canopy LIDAR) system have and will greatly enhance numerous fundamental environmental applications. Development and deployment of these and other systems (e.g. improved radar systems) should be fostered in such a way that the data and information extraction techniques are widely available for use in environmental and other applications. Likewise, the commercial satellite systems are beginning to provide economically viable options to airborne systems, when high-resolution multi- and hyperspectral data are required for environmental applications. Just as synergistic partnerships have been created between the commercial, government and university sectors to develop increased capacity for environmental applications, creative ways should be explored to make more widely available (i.e. more cost effective) the capabilities of existing and soon to be launched commercial satellite systems.

Numerous presentations indicated that the full capabilities of remote sensing to provide effective environmental data are best realized when the most appropriate data from multiple remote sensing systems is effectively integrated. More environmental scientists need a greater awareness and understanding of the wide variety of environmental information that can be derived from using individual or combinations of remote sensing systems. In short, remote sensing is not being used to its full potential by those with missions to develop and analyze environmental data. Activities that foster the understanding and use of remote sensing for environmental and other applications within governmental agencies and among their partners should be encouraged and supported.

One example of such an undertaking is the activities of the USGS Land Observation Activities (LOA) Ad Hoc Working Group. An executive summary of this group's white paper defining the situation and potential courses of action is attached for further reference.

<u>LOA White Paper - Executive Summary</u>

- Remotely sensed data are fundamental tools for studying the Earth's land surface, including coastal and near-shore environments. They are sources of information from which can be made meaningful interpretations about the Earth's biologic conditions and resources, geologic and hydrologic processes and resources, topographic and geographic features, and human dynamics.

- Aerial remote sensing has been a basic USGS mapping tool for more than half a century, and the USGS has played important roles in satellite remote sensing since before the launch of Landsat 1 in 1972. The USGS has received, processed, archived, and distributed, to countless users around the world, Landsat and other satellite and airborne remotely sensed data and products. For even longer, scientists and managers from the USGS and other DOI bureaus have used Landsat and other civil and classified remotely sensed data in many research, applications, and operational endeavors important to USGS and DOI programmatic objectives.

- Nevertheless, the full potential <u>benefits</u> of remotely sensed data and remote sensing technology for most USGS and DOI programs and activities have yet to be realized, because various obstacles have inhibited wider utilization of the data and technology. Those obstacles include lack of remote sensing knowledge and experience, cost of data, frustration with data search and order tools, lack of experience and expertise with data analysis and interpretation techniques, and lack of access to analysis tools and/or appropriate field equipment. These obstacles can be overcome by expanding certain land observation activities (LOA's).

- The goal of the LOA effort is to **enhance** earth and biological **science** *through better utilization of remotely sensed data and remote sensing technology*. This includes enhancing the effectiveness of operational and applied programs through expanded use of the data and technology. Initially, this goal focuses on the USGS, but efforts should grow to support other DOI bureaus in the near future and, eventually, other Federal civil land-management agencies.

- To accomplish this goal, activities that address and serve to meet the requirements of current and potential USGS and DOI research, applications, and operational users of remotely sensed data must be defined and implemented.

- To optimize chances for success, it is imperative that such remote sensing support activities, <u>and</u> the requirements they are designed to meet, ***be defined by*** the scientists and managers whom they will serve. Securing the meaningful participation of the USGS grassroots user community in this process will not be a trivial task, but it is an important and necessary one.

- Examples of support activities that <u>*might*</u> be defined and implemented include: compile user requirements, enhance access to data, educate and train users, facilitate remote sensing R&D, enhance operational programs, be the USGS/DOI remote sensing advocate, liaison with management, and others.

- A road map is needed for taking the USGS from the current introductory LOA concepts to the valuable baseline activities they could become. It should define the specific functions that will constitute LOA's, including the relative priorities for those functions to guide their phased implementation. The road-map-building process needs to consider alternative organizational and operational structures and recommend one as the most suitable for expanding LOA's. It also should propose a general schedule for implementing the operational framework. Finally, the process should address LOA funding and recommend a viable and sufficient funding scenario that will not be so controversial as to undermine program support.

- The first step in the definition process has been to establish an ad-hoc working group of USGS scientists and managers with extensive experience and/or interest in remote sensing applications. The LOA Ad Hoc Working Group, with membership from each of the four major USGS disciplines held its initial meeting in Denver on August 1 and 2. A summary of the discussions and results is available.

- The primary purposes of the Ad Hoc Working Group are 1) to add credibility and momentum to the LOA concept and efforts by establishing coordinated, ***bureau-wide*** participation and endorsement; 2) to establish a vision or goal for the role of remote sensing in the USGS; 3) to define tangible short-term milestones that will begin to take LOA from concept to reality; 4) to provide USGS management with specific recommendations regarding the future development of LOA.

The LOA Ad Hoc Working Group should be succeeded by a "Land Observation Activities Steering Committee" to oversee the LOA definition and implementation process, including to ensure full engagement of the USGS grassroots user community and appropriate USGS management in that process.